

NOTES ON AUSTRALIAN MOSQUITOES (DIPTERA, CULICIDAE).

Part i. THE ANOPHELINI OF THE MAINLAND.

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(Three Text-figures.)

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The valuable revision of the Australasian Culicidae by Edwards (1924) has placed our knowledge of the family on a sound basis and enabled Australian workers to undertake the study of local problems with some degree of confidence. In this series of papers it is hoped to clear up some of the taxonomic problems which he left obscure, largely because of the inaccessibility of the Macleay types, to discuss the status and relationships of a number of species, and to add such fresh information as is available with regard to distribution, habits and life histories.

Edwards's work was soon followed up by Hill (1925), who made a very full and detailed study of the status and distribution of the *Anopheles* of the *Myzomyia* group with special reference to those occurring in Northern Australia and the adjacent islands. In the present paper his work is extended, special attention being paid to the males and larvae. The status of the various forms of *A. annulipes* Walk. is discussed and the opinion expressed by Hill (1925) and Ferguson (1926) as to the synonymy of *A. mastersi* Sk. with this form is confirmed. Keys are given to the females and larvae of all species occurring on the mainland and figures of, and notes on, the male hypopygia. The life histories of *A. atratipes* Sk. and *A. stigmaticus* Sk. and the larva of *A. amictus* Edw. are described for the first time.

A very great deal of material has been available for study, and I wish particularly to express my indebtedness to Dr. E. W. Ferguson for advice and for the use of material and to Mr. H. Hacker of the Queensland Museum for the opportunity of examining the fine series of northern forms of *A. annulipes* Walk., of *A. amictus* Edw. and of *A. corethroides* Theo. in their collection, without which this paper could not have been nearly as complete as it is.

Key to Adult Females.

1. Conspicuously ornamented species with numerous white markings on wings and legs. (Subgenus *Myzomyia*) 2
More concolorous brown or black species. (Subgenus *Anopheles*) 6
2. Pale apical half of the antepenultimate segment of the palpi divided by a dark ring *punctulatus* Don.
Pale apical half of the palpi continuous and without such ring 3
3. Proboscis pale on at least portion of the apical half *annulipes* Walk. (part)
Proboscis entirely dark 4
4. Abdominal tergites 2-7 devoid of scales *annulipes* Walk. (part)
Abdominal tergites 2-7 with numerous flat pale scales 5

5. Tarsi apically banded only *amictus* Edw.
 Tarsi apically and basally banded *amictus* Edw. Type C, Hill.
6. Small brown species with the basal four-fifths of the hind femora creamy to yellow anteriorly *stigmaticus* Sk.
 Larger black species with the femora not so marked 7
7. Palpi with bushy outstanding scales; wing with a white spot beyond the middle of the costa; hind tarsi with narrow white rings *bancrofti* Giles.
 Palpi normal; costa without such spot; hind tarsi entirely dark *atrapiques* Sk.

Key to Larvae.

1. Inner anterior clypeal hairs widely separated and closer to the outer anterior clypeal hairs than to each other (Subgenus *Myzomyia*) 2
 Inner anterior clypeal hairs very close together (Subgenus *Anopheles*) 4
2. Posterior clypeal hairs closer together than the inner anterior and projecting well beyond the head *amictus* Edw.
 Posterior clypeal hairs wider apart than the inner anterior and not reaching to the anterior margin of the head 3
3. Posterior clypeal and inner occipital hairs multiple *annulipes* Walk.
 Posterior clypeal and inner occipital hairs single *punctulatus* Don.
4. Outer anterior clypeal hair strongly branched *bancrofti* Giles.
 Outer anterior clypeal hair single 5
5. Larger black larvae with the antennal plume large and strongly branched
 *atrapiques* Sk.
 Small brown larvae with the antennal plume very small and finely branched
 *stigmaticus* Sk.

Note.—*A. punctulatus* Don. is included in the keys since it has been recorded from the extreme north of the mainland. The characters available from the descriptions for the separation of its larva are not all that might be desired; a critical reexamination of this species will probably reveal others of greater value. It is to be noted that the above key to adults will *not* apply to males of the *Myzomyia* group; comparison with known females and a critical examination of the palpal and leg markings, of the abdominal scaling, and especially of the hypopygium are the only means of placing specimens of this sex.

ANOPHELES (ANOPIELES) ANNULIPES Walker.

This is the common species on the mainland. Its range is from Cairns to Tasmania and it is found in the dry inland districts and on the mountains to a height of 5,000 feet as well as being common in the coastal area. Records from the islands to the north of Australia require confirmation; most, if not all, undoubtedly refer to other species of the group. In the southern part of its range it is the only member of the subgenus met with, but in South Queensland *A. amictus* Edw. appears in company with it and gradually replaces it further north. *A. annulipes* Walk. bites chiefly in the evening and at night but occasionally also in the middle of the day; its resting attitude is about 45° with the surface. This species is a presumed malaria carrier in Australia. The evidence for its relation to the sporadic cases which have occurred in New South Wales is very strong, particularly so in a recent infection acquired at Narrabeen, near Sydney (Money, 1926). In Queensland, however, the question is more obscure, since *A. annulipes* Walk. and *A. amictus* Edw. have been confused in the past and either or both may be carriers, while *A. bancrofti* Giles must also be considered as a probable vector.

In the female sex three main types may be recognized:

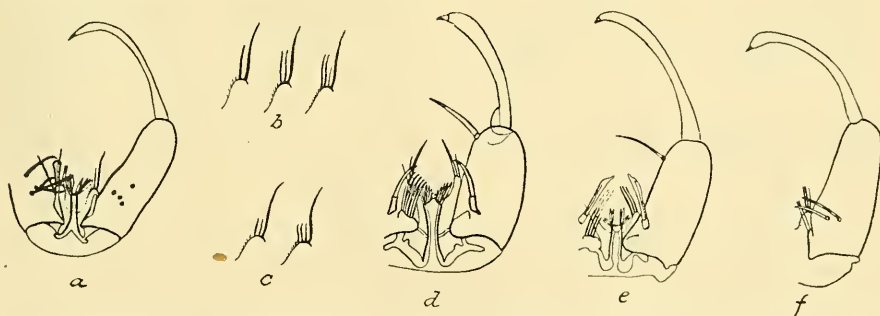
1. Specimens with the proboscis entirely dark and the abdomen devoid of scales on tergites 2-7. This is the typical *annulipes* Walk., and is found in Tasmania, in the coastal districts of the mainland south of Sydney more particularly in the cooler months, and on the mountains. It is relatively rare.

2. Specimens with the proboscis pale on the apical half or less and with few or no scales on tergites 2-7 of the abdomen. This is the *mastersi* Sk. form and is by far the most common type throughout the entire range of the species except possibly in the extreme south and north.
3. Specimens with the proboscis pale on the apical half and with more or less numerous pale scales on tergites 2-7 of the abdomen. These scales are usually narrow, but may be flat and fairly broad though always distinctly narrower than those seen in *A. amictus* Edw. This form is common in the north, but also occurs in New South Wales, where, however, it is distinctly rare.

It is to be noted that all stages linking 1 to 2 and 2 to 3 are present in the very extensive series I have examined, but none linking 1 to 3. It appears that the *mastersi* type is the continuous dominant form and that there is a tendency to differentiate out, at the one end of the range into a type with an entirely dark proboscis, and at the other into a type with scales on the abdominal tergites. In the opinion of the writer this process has certainly not gone sufficiently far to warrant giving varietal or subspecific names to the different forms.

Females of *A. amictus* Edw. are easily separated from any of the above three types by possessing *both* an entirely dark proboscis and numerous pale flat scales on tergites 2-7 of the abdomen.

In the case of the males the proboscis is always entirely dark or almost so; consequently it is only possible to recognize two types, one with scales on the abdominal tergites and one without. There is here also every stage linking the two groups and the hypopygium is constant throughout the entire series. Males with numerous scales on the abdominal tergites are difficult to separate from *A. amictus* Edw., but may be distinguished by the fact that in *A. annulipes* Walk. the scales are markedly narrower and usually less numerous and of course by the hypopygial characters.

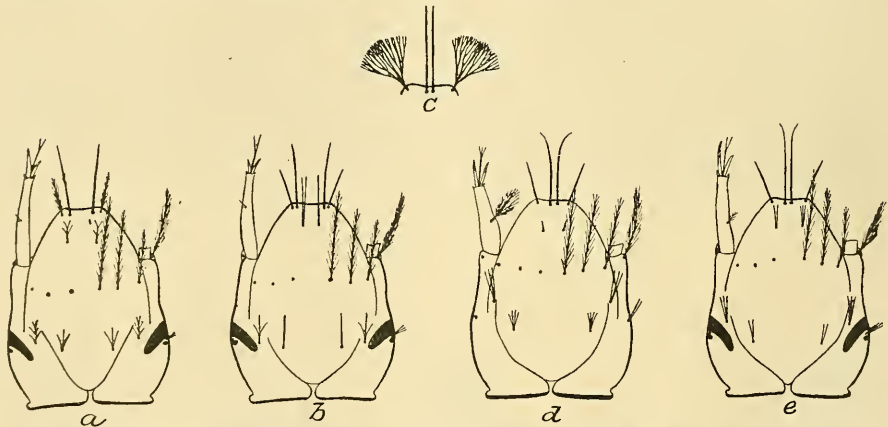


Text-figure 1.—*a* Hypopygium of *A. annulipes* Walk.; *b* Claspettes of three specimens of same; *c* Claspettes of two specimens of *A. amictus* Edw.; *d* Hypopygium of *A. stigmaticus* Sk.; *e* Hypopygium of *A. atratipes* Sk.; *f* Side-piece and its appendages of *A. bancrofti* Giles.

The side-piece of the male hypopygium (Text-fig. 1 *a*) bears four basal spines usually arranged as in the figure though there is some variation. The leaflets are four or five in number and are rather broad; they are about half the length of the aedeagus. The claspette is rounded and there is some variation in the arrangement of its setae. Edwards (1924) describes this structure as bearing a long apical hair and a single accessory one which is at least half as long as the apical one; this arrangement is frequently met with, but many specimens have two accessory hairs half as long as the apical one, and sometimes also a third which is a little shorter than the others. Variations are met with in the two

sides of the one specimen. *The length of at least one or two of the accessory hairs is constantly as much as half the length of the main hair in all specimens examined, an important point of distinction from A. amictus Edw. in which these accessory hairs are never more than a quarter the length of the main hair (compare Text-fig. 1 b and c).*

The larvae usually live in clear water, preferably in soakage pools and small swamps in which there is some algal growth, but they may also be found (more often in Queensland than in New South Wales) in rock pools, in muddy creeks and waterholes, and even in somewhat polluted water. I have twice taken them in running water, in the Burnett River at Eidsvold, S. Queensland, and in the upper Hunter River, N.S.W. In both instances they were clinging, presumably by means of their caudal grappling hooks, to filamentous algae in shallow water where the flow was not very rapid. At Eidsvold the alga was a species of *Spirogyra* and the association was almost as close as that seen in the case of *C. basicinctus* Edw. and *C. bitaeniorhynchus* Giles, the larvae remaining submerged for long periods attached to the alga, from which apparently they drew their oxygen as well as their food supply. This adaptation is distinctly curious in view of the more usual surface-living habits of the species.



Text-figure 2.—Heads of larvae of a *A. annulipes* Walk.; b *A. amictus* Edw.; c *A. bancrofti* Giles (after Cooling); d *A. atratipes* Sk.; e *A. stigmaticus* Sk.

Cooling's (1924a, 1924b) descriptions of the larva and pupa are rather incomplete and these notes and figures are intended to amplify his. The head is brown and has the pigment arranged in a definite and rather characteristic pattern, not uniformly distributed as in the species of the subgenus *Anopheles* described below. The antenna bears a short sublateral spine about the middle of its length. The cephalic chaetotaxy appears to afford the only reliable characters for the separation of the related species and is shown in Text-fig. 2 a. The inner anterior clypeal hairs are set well apart and much nearer to the outer anterior clypeal hairs than to each other; they sometimes bear two or three very short, fine plumes which are hardly longer than the diameter of the hair. The outer anterior clypeal hairs are about two-thirds the length of the inner and are strongly plumose; in one specimen, probably as an aberration, these hairs were strongly branched. The posterior clypeal hairs are set further apart than the inner anterior, have four branches, are short and do not project as far as the

anterior border of the head. The frontal and subantennal hairs are normal. The inner occipital hair is trifid and the outer one bears a few plumes. The palmate hairs and other characters agree with Cooling's descriptions and figures; they do not appear to offer any assistance in discriminating between the related species. The pecten (in the sense used by Christophers) bears three long teeth as well as the end ones, but is somewhat variable.

The pupal skin is brown and bears no specially pigmented areas, except for the trumpet which is lightly powdered with pigment. The abdominal chaetotaxy is shown in Text-fig. 3 *a* and does not require further description; its characters are most valuable for the recognition of the pupae; the stout lateral spines decrease in size proximally and are very short on the basal segments. The trumpet (Text-fig. 3 *d*) is oblong in shape and is slightly shorter and broader than that of *A. stigmaticus* Sk.

ANOPHELES (MYZOMYIA) AMICTUS Edwards.

A larger, more yellowish species than *A. annulipes* Walk., from which it is to be distinguished in the female by the combination of an entirely dark proboscis with numerous scales on abdominal tergites 2-7, and in the male by the hypopygium. The claspette bears two or three fine short hairs which are always less than one-quarter the length of the main hair (Text-fig. 1 *c* and *b*). The abdominal scales of both sexes are broad, flat, and yellowish in colour. These characters might be considered as very doubtfully of specific value, even though constant, and the statement by Hill (1925) that he obtained typical females of *A. annulipes* Walk. among the progeny of *A. amictus* Edw. females would undoubtedly lead one to sink the latter name as a synonym, were not the question further complicated by the discovery that the larvae are very distinct. In view of this one cannot but let Edwards's name stand until the whole question can be reinvestigated and Hill's breeding experiments repeated and extended with special reference to the males and early stages.

I have only seen females of Hill's type "C." This form is easily recognizable on this sex and an examination of the males and early stages may possibly prove it to be distinct.

The larvae (of the typical form) were found in company with those of *A. annulipes* Walk. and *C. basicinctus* Edw. associated with green algae in running water in the Burnett River at Eidsvold. They were never found in any other situation in this district. They differ from *A. annulipes* Walk. in the following respects (Text-fig. 2 *b*): The sublateral spine of the antenna is definitely beyond the middle; the outer anterior clypeal hairs are single (unplumed) and the posterior clypeal hairs are single, or sometimes bifurcate, and extend well beyond the anterior margin of the head; the inner occipital hair is single and the outer is trifid; the comb differs slightly in the arrangement of the long spines, but is variable; in other respects, including the palmate hairs, there is little or no distinction. Unfortunately the pupae were not preserved.

The biting habits and resting attitude of the adult females are, so far as my experience goes, similar to those of *A. annulipes* Walk.

Distribution.—*A. amictus* Edw. has been recorded from North Queensland and the Northern Territory. I have also taken it at Eidsvold, S. Queensland (April, 1924, bred from larvae, also biting after dusk) and there are specimens in the Queensland Museum from the following localities in Queensland: Charleville, June, 1899, C. J. Wild; Eidsvold, March, 1915, Bancroft; Brisbane, April, 1912,

H. Hacker; Cunnamulla, May, 1899, C. J. Wild. It would appear that in the southern part of its range, which by the way is much more extensive than was formerly thought, it is much less abundant and appears much later in the season than further north.

ANOPHELES (ANOPHELES) BANCROFTI Giles.

There is no fresh information to add concerning this species. Adults and the larvae are readily recognizable by the characters given in the keys. The larva and the pupa have been described by Cooling (1921, 1924*b*). The latter stage is somewhat difficult to recognize, but is apparently similar to *A. atratipes* Sk. from which it is to be separated by the markedly smaller paddles and probably different chaetotaxy; further material is desirable. The male genitalia have been described by Edwards (1924). Text-fig. 1 *f* was drawn from a male from the Sepik River, Mandated Territory of New Guinea (R. W. Cilento) which agreed in all respects with typical females from the mainland and with Edwards's description of the hypopygium.

ANOPHELES (ANOPHELES) ATRATIPES Skuse.

A rather uncommon species which was hitherto known only from females. Superficially it resembles *A. bancrofti* Giles, but is easily separable by the palpal clothing and by the wing and leg markings. Its habits, too, are somewhat similar in that it is a sylvan day-biting species which rests at an angle of about 80° with the surface. It is most prevalent in the coastal districts of New South Wales and South Queensland in spring and early summer, apparently disappearing completely later in the season when other Anophelines are most abundant. In the Sydney district it occurs most frequently in the sandstone gullies and in the vicinity of sluggish creeks running through the Pleistocene sand flats. At Dunwich, Stradbroke Is., South Queensland, females were common in September, 1926, along the course of a sluggish creek in which there were moderate numbers of the larvae. A prolonged search was made among the vegetation, on the sheltered sides of logs and tree trunks, and in similar likely situations, but not a single adult male was seen. Neither males nor larvae have been found in any other locality, even where females were not uncommon.

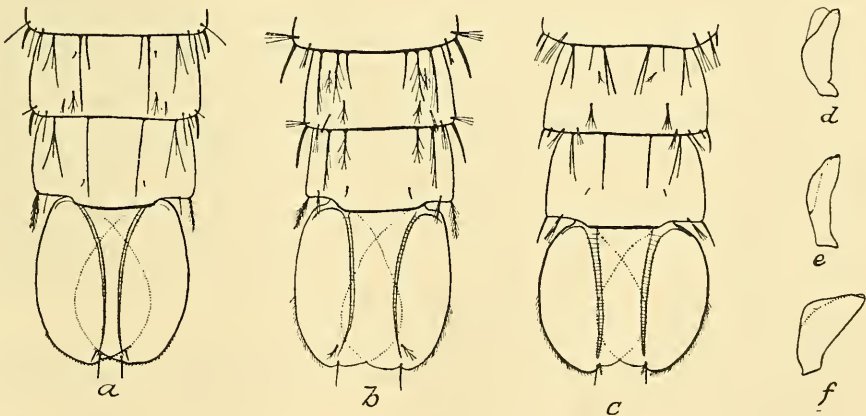
♂. Palpi with the terminal segment swollen and with a patch of long hairs ventrolaterally on the basal half of the terminal segment and extending on to the apical part of the penultimate segment; antennae with long, dense, silky, brown plumes; otherwise resembling the female in all essentials. The hypopygial characters (Text-fig. 1 *e*) are in some respects intermediate between *A. bancrofti* Giles and *A. stigmaticus* Sk., but show much closer affinities with the latter in the single basal spine of the side-piece, in the pointed rather than lobed claspettes, and in the replacement of the club by a row of four basal spines set on a lobe. It resembles *A. bancrofti* Giles in bearing three subequal spines on the claspette. There are about two pairs each of longer medial and shorter lateral leaflets. The allotype male (Dunwich, Stradbroke Is., South Queensland, bred from larvae, 10th Sept., 1926) is in the Macleay Museum, University of Sydney.

The larvae were taken in a small, sluggish, slightly muddy creek with a fine silt bottom. The pH of a sample of the water was 7.5. (This determination was kindly made for me by Dr. R. Hamlyn-Harris, City Entomologist, Brisbane, who was also good enough to breed through a number of larvae brought back from Dunwich.) Some aquatic vegetation was present, but not a great deal. Other

mosquito larvae were entirely absent, although adults of several species were common along the banks. The local distribution of the species in the Sydney district suggests that it breeds in similar situations and also in pools in sandstone creeks.

The larvae are darker than those of *A. annulipes* Walk., but do not afford any naked eye characters of value for differentiating them. The antennae (Text-fig. 2 *d*) are brown, notably stout and short, and bear apically two spines and a fine trifid hair. The antennal hair is situated slightly basal to the middle, is fully half the length of the antenna and is strongly branched. The head is very heavily and uniformly pigmented and no trace of eyes could be made out in any of the preparations. The anterior clypeal hairs resemble those of *A. stigmaticus* Sk., but the posterior are very short and single. The frontal hairs are strongly plumed and are subequal in length. The subantennal plume is normal. The inner occipital hair is divided into four very fine branches. The outer lies well anterior to the middle and is trifid. The thoracic and abdominal chaetotaxy is not remarkable except for the entire absence or great reduction of the palmate hairs. These structures may be represented by certain short hairs on a few of the abdominal segments, but are certainly not present in the form seen in other Anopheline larvae. The pecten consists in general of long spines alternating with two very short ones. Grappling hooks are developed.

The affinities of the larva are with *A. stigmaticus* Sk., from which it is to be separated by its larger size, much darker colour, much stronger antennal plume, and by the absence of eyes or palmate hairs, a most remarkable and unexpected feature of these larvae.



Text-figure 3.—Terminal segments of pupa of *a* *A. annulipes* Walk.; *b* *A. stigmaticus* Sk.; *c* *A. atratipes* Sk. Lateral view of trumpets of *d* *A. annulipes* Walk.; *e* *A. stigmaticus* Sk.; *f* *A. atratipes* Sk.

The pupa appears to be closest to Cooling's description of *A. bancrofti* Giles. The skin is brown with strong lines of black pigment on the wing sheath along the course of the veins and with transverse dark bars in a row along the antennal sheath. The trumpet (Text-fig. 3 *f*) is very broad, triangular in shape, and is deeply pigmented. This species is apparently separable from *A. bancrofti* Giles

by its larger paddles and probably different abdominal chaetotaxy and from all other Australian species by the broad triangular trumpet, by the pigmentation of the cephalothorax and by the chaetotaxy (Text-fig. 3 c).

It is interesting that this species should resemble *A. bancrofti* Giles fairly closely in the general characters of the adults and in the pupa, but yet show much closer affinities with *A. stigmaticus* Sk. on hypopygial and larval characters which are undoubtedly more reliable.

ANOPHELES (ANOPHELES) STIGMATICUS Skuse.

This is a very rare, small brown species of which I have been fortunate in obtaining a good series of both sexes and of the larvae and pupae at National Park, New South Wales. They were only found in a patch of brush growing on the Narrabeen series near Waterfall. Adults were taken by stirring them out of the grass and bushes and at no time showed any inclination to bite. Their resting attitude is almost horizontal and the palpi are carried closely appressed to the proboscis so that they resemble when alive a small species of *Culex* much more than an Anopheline.

Specimens were compared with the types of *A. stigmaticus* Sk. and found to agree with them in every particular. The most striking features of this species are the pale yellow basal four-fifths of the hind femora and the conspicuous dark patch covering the forking of R and Rs. These characters are not mentioned by Theobald in his description of *A. corethroides* Theo. and the stems of the fork cells are distinctly longer than is indicated in his description. Skuse's description is complete and accurate except for the markings on the mesonotum which are correctly described by Theobald. A male in the Queensland Museum from Burpengary, South Queensland (Bancroft) is from the type locality of *A. corethroides* Theo. and agrees very well with his description. It agrees completely in genitalic characters with typical *A. stigmaticus* Sk., but differs in markings in that the dark patch on the wing is absent and the pale areas on the hind femora are less extensive and creamy white rather than pale yellow. Of the four other specimens from Queensland in the same collection, two are similar to the male from Burpengary, one corresponds to the southern form, and one is intermediate. These were all collected by Dr. Bancroft and are probably from the vicinity of the type locality. The genitalia of both northern and southern forms (Text-fig. 1 d is from a National Park specimen) agree with Edwards's (1924) description of the type of *A. corethroides* Theo. There is no doubt that the synonymy given by Edwards is correct, but the typical *corethroides* form is distinctly less well marked than typical *stigmaticus*.

The distribution is from South Queensland to National Park and the Blue Mountains in New South Wales. The National Park specimens were taken in April, 1925, and January, 1926.

The larvae were found associated with *A. annulipes* Walk. in small pools containing filamentous algae in the bed of a small creek which ran through the brush and had cut down to the Narrabeen sandstone. They are small, brown in colour, and superficially resemble small specimens of *A. annulipes* Walk., naked eye separation of the two being impossible. The antennae are creamy, darker at the tip, and bear apically two spines and a single fine hair which is forked distally; the antennal hair is situated at the junction of the basal and middle thirds of the antennal length and is very short and finely branched. The head is uniformly dark brown in colour and both compound and simple eyes are present. The inner

anterior clypeal hairs are long, bare, and set close together; the outer anterior clypeal hairs are a little more than half the length of the inner and are bare; the posterior clypeal hairs are short and single or divided into two or three very fine terminal branches. The frontal and subantennal hairs are normal. The inner occipital hair is bifid and the outer lies well anterior to it and is trifid. The chaetotaxy of the thorax and abdomen is not unusual. Palmate hairs occur on segments 2-7 of the abdomen, are well developed and conspicuous, and each consists of 20-25 leaflets which are long, slender, pointed, and not serrated. The pecten is composed of regularly alternating long and short teeth. The ventral subdorsal hairs bear the usual grappling hooks.

The pupal skin is a clear pale brown and the trumpet is not pigmented nor are there any zones of pigmentation on the cephalo-thorax. This stage may usually be separated from that of *A. annulipes* Walk. by its smaller size and paler colour. The trumpet (Text-fig. 3 e) is longer and not so broad, and the abdominal chaetotaxy (Text-fig. 3 b) is strikingly different. From *A. atratipes* Sk. it may be distinguished by its smaller size, absence of pigmentation, much narrower trumpet, and different chaetotaxy. The pupal stage lasted two to four days under the conditions of the experiments.

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